“SMART STREETLIGHT MANAGEMENT SYSTEM”

Idea Lab Report

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS & COMMUNICATION ENGINEERING

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CERTIFICATE

This is to certify that the Idea Lab Project Report entitled **"Smart Street Light Management System"** submitted by **Sahil Tulsiani (17BEC093), Dhruv Shah (17BEC097) and Jainam Shah (17BEC099)** towards the partial fulfillment of the requirements for the Idea Lab in Institute Of Technology of Nirma University is the record of work carried out by him/her under our supervision and guidance. The work submitted has in our opinion reached a level required for being accepted for examination. The results embodied in this major project work to the best of our knowledge have not been submitted to any other University or Institution for award of any degree or diploma.

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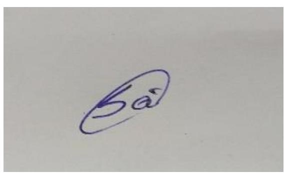
Undertaking for Originality of the Work

We, **Sahil Tulsiani (17BEC093), Dhruv Shah** (**17BEC097**) and **Jainam Shah** (**17BEC099**), give undertaking that the Major Project entitled **"Smart Street Light Management System"** submitted by us, towards the partial fulfillment of the requirements for Idea Lab in **Institute Of Technology** of Nirma University, Ahmedabad, is the original work carried out by us and we give assurance that no attempt of plagiarism has been made. We understand that in the event of any similarity found subsequently with any other published work or any project report elsewhere; it will result in severe disciplinary action.



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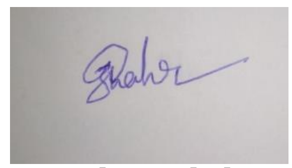

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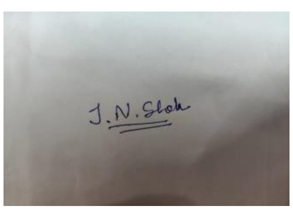

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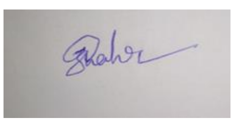

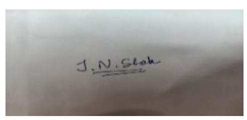

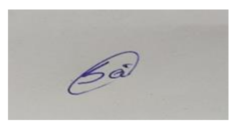

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ABSTRACT

Energy conservation has already become a very essential requirement in this world. As we advance with new and new technologies to the future, the dependence on energy for humankind is continuously increasing as well. This continuous growth of the dependence on energy comes at very high cost such as increased CO2 emissions, pollution and global warming as well. So it is needed that we develop such systems which can be used to reduce the energy consumption for different applications. Electricity is a very vital form of energy. So, in order to reduce the electricity consumption, we propose a system which can be implemented on street lights considering the conditions of the premises and requirements where streetlights are situated and this will help to reduce the electricity consumption effectively. To address this issue, we have tried to design and develop a Smart Street Light Management System which basically works with object detection and pseudo prediction based on signal transmission system with configurable timing requirements. This paper includes the detailed explanation of the problem, our approach to the problem, detailed explanation of the solution, the effectiveness and various advantages of the proposed system. The proposed system prototype has been successfully developed, implemented and tested and it is compact, cost-effective, consists configurable aspects based on the conditions of the premises and has given satisfactory results.

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NOMENCLATURE

ABBREVIATION

LED	Light Emitting Diode
PIR	Passive Infrared
RTC	Real Time Clock
IDE	Integrated Development Environment
LNA	Low Noise Amplifier
WiFi	Wireless Fidelity
SPI	Serial Peripheral Interface
UV	Ultra Violet
EDA	Electronic Design Automation
IoT	Internet Of Things

Chapter 1
Introduction

1.1 Introduction

. In this project, we propose a smart streetlight management system which is easy to implement and is a low-cost system. The proposed system can be implemented in such streets and such premises where it is not required to keep lights continuously on the streets for a particular duration of night. Our proposed system is based on object detection, radio transmission along with implemented configurable time constraints based on the premised conditions. It is managed by microcontrollers and it consumes very less power to work and also can be easily configured with the existing electric streetlight system. By implementing our system, we can reduce electricity consumption at low cost and can reduce energy consumption at the same time providing lighting as usual so there will not be any security or blackout issue when any pedestrian or vehicles are passing by. Our proposed system design is able to solve the issues like cost, integrability, feasibility, size and configurability with the premises' conditions and environment.

Our system design is focused for such premises like schools, colleges, industrial parks and particular streets where it is not needed to keep the streetlights on throughout the duration of night.

As we know that in particular streets or some premises like colleges, schools or some industrial parks and many more places where it is not needed to keep the streetlights (LEDs) ON throughout the night which consume a lot of electricity although this is not needed as there are very less pedestrians or vehicles passing by. So, by implementing our system to the current lighting system at very low cost and easy implementation, we can reduce the ON hours of streetlights and hence can achieve several advantages.

1.2 Motivation

Energy has already become the most important element of human life. And electricity is the most vital form of electricity. Electricity is being produced from renewable and non-renewable resources. We already know various disadvantages of generating electricity from non-renewable resources like global warming and its effects along with the pollution and its harmful effects on the environment and also the human health. Whereas generating electricity from renewable resources is costly and they demand costly infrastructure and it also depends upon different environmental conditions. So, it is essential to reduce the electricity consumption itself by developing various applications-based technologies which are easy to implement and also cost-effective. In this paper, we focus on the same concept of reducing electricity consumption on one of the very vital applications which is based on electricity and also consumes around 20 to 40% consumption of total electricity production globally [1]. The said application is streetlights.

A brief case study is explained below which gives us an estimate of how much cost or how much electricity we can save by implementing the proposed system. By 2020, in India LED streetlights are going to cross the mark of 1.34 Cr [2]. And we can apply the proposed system to most of the streetlights but even if we apply the proposed system to only a few of them in particular premises stated above then also we can save up a lot of electricity. And as different studies state that 15 to 40% of total energy consumption is consumed by streetlights in prime cities. A study-based calculation is explained below which explains the consumption of electricity units and cost a LED streetlight consumes in a year and after implementing our system the amount of electricity which can be saved and so the cost as well per year per streetlight.

As per Torrent Power (Ahmedabad city), per unit cost of electricity is 4.9 Rs/unit overall [3]. Considering that one 40-watt LED street light stays on from 7 pm to 5 am i.e., 10 hours per day, electrical units consumed in a year is 40W x 10 hours x 365 days, which is equivalent to 146 kWh or 146 units. And considering per unit cost of 4.9 Rs/Unit, the effective cost consumed by a street light in a year (Actual Calculations may differ on practical approach) is approximately 715.40 Rs. Now if we save about only 2 hours (actual duration can be around 4 to 5 hours' minimum considering 12 am to 4 or 5 am) of energy every day, number of electrical units saved in 365 days is about 2 hours x 365 days x 40W which is equivalent of 29.2kWh or 29.2 Units. And thus effective cost saved per streetlight per year is 29.2 Units x 4.9 Rs/Unit which is equivalent to 142.35 Rs.

So, by our proposed idea, if we save 29.2 kWh per annum per streetlight, the scaled amount is going to be very high leading us to achieve energy conservation to a massive amount and a considerable amount of reduction in CO_2 emission.

1.3 Objectives

The following objectives are needed as a guidance in order to achieve the goal of our project. They are:

- To interface Arduino, PIR Sensor, RTC Module, nRF24L01 and LED.
- To detect objects within range from infrared waves of PIR Sensor.
- To transmit and receive the signal by the use of transmission module to different street lights.
- To manage the time duration for which street lights are turned on.
- To streetlight to remain on for the duration as programmed in the Arduino.

Chapter 2
Specifications of Components

In this project, Arduino, PIR Sensor, RTC Module, nRF24L01 Transceiver Module and LED are used. Working and specifications of such modules are discussed as below.

TABLE I

COMPONENTS' PARAMETERS

Index	Name	Voltage	Current	Range
1	Arduino	7-12V	40mA	-
2	nRF24L01	1.9-3.6V	13.5mA	30m
3	PIR sensor	3-5V	65mA	5m
4	RTC module	3.3V	300μA	-
5	LED	3.3V	12mA	-

2.1 Arduino Uno

In this project, Arduino is used as a mediator between Transceiver module, RTC Module, PIR Sensor and LED. We are using Arduino UNO for simplicity and low cost purpose but a higher version of microcontroller can be used for the better results in actual life or actual environment implementations

Figure 2(a): Arduino Uno

“Arduino Uno” module is used in this project which is a microcontroller board, consisting ATmega328P microprocessor and several peripherals for various purposes. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator to provide clock pulses, a USB connection, a power jack and a reset button. Arduino Uno is used which is one to of the most basic and simpler microcontroller to use. The main advantage of Arduino is low cost (Around-₹420) and easy to program it and also it is user friendly in sense of connections and the open source IDE available with it. It helps in many ways like getting outputs from serial monitor, debugging the program, use of different instructions and so on. Also, Arduino is open source and the community that helps in various problems like getting information about different functions and instructions and the basic examples and libraries of Arduino IDE are also very useful. Also providing the ability of configuring peripherals devices with it boosts up a lot of simplicity. Different types of communication schemes like Serial SPI and I2C and several other features on same board makes Arduino a lot more efficient and configurable than a single microcontroller. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.[4]

Microcontroller	ATmega328P 8-bit
Operating Voltage	5V
Recommended Input Voltage	7-12V
Input Voltage Limits	6-20V
Analog Input Pins	6(A0-A5)
Digital I/O Pins	14(6 for PWM)
DC current on I/O pins	40 mA
Flash Memory	32 KB (0.5 KB for Bootloader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz
Serial Communication Pins	0(Rx), 1(Tx)

Table II: Arduino Specifications

2.1.1 Pins

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

- External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details.
- PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite () function.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it' s off.
- The Uno has 6 analog inputs, labelled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default, they measure from ground to 5 volts, though is it possible to change the upper end of their range using the
- AREF pin and the analogReference () function. Additionally, some pins have specialized functionality.
- TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.
- There are a couple of other pins on the board: AREF. Reference voltage for the analog inputs. Used with analogReference ().
- Reset. Bring this line LOW to reset the microcontroller.

2.2 nRF24L01 Transceiver Module

For radio signal transmission, we use nRF24L01 module but for greater range and efficiency we can use nRF24L01 with LNA and an external antenna which can increase the range. Although the current module without any external attachment has the range of more than 30m as measured practically and if the radio transmission takes place in line of sight then range can be measured near to 100m as well.

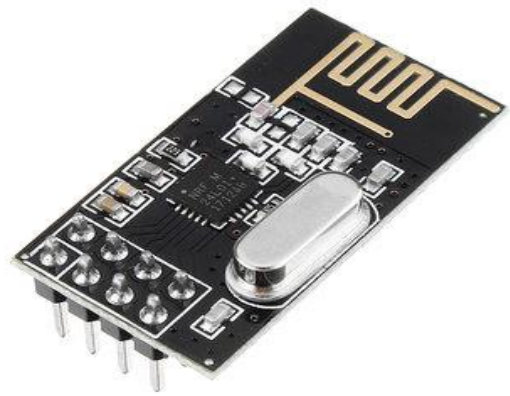

Figure: 2(b): nRF24L01 Transceiver Module

The nRF24l01 module is a low-power transceiver that enables wireless data exchange over the 2.4GHz radio frequency band. It allows efficient communication between two devices over a medium distance (50m) when they are in direct view, i.e. without obstacles. If you wish to communicate over longer distances outdoors, an RF433 module should be preferred. Indoors, if one or more walls are present between the transmitter and the receiver, it is preferable to use WiFi or Bluetooth communication.[5]

The nRF24L01 module uses the SPI protocol to communicate with the microcontroller and must be powered between 1.9 and 3.6V. SPI communication uses specific boxes and is pinned as follows (left side NRF24L01, right side Arduino UNO):

- Vcc (Power) : 3V3
- CE (Reset) : 2
- GND (ground) : GND
- MOSI (Master Output Slave Input) : 11
- MISO (Master Input Slave Output) : 12
- SCK (Serial Clock) : 13
- CS (chip select) : 4

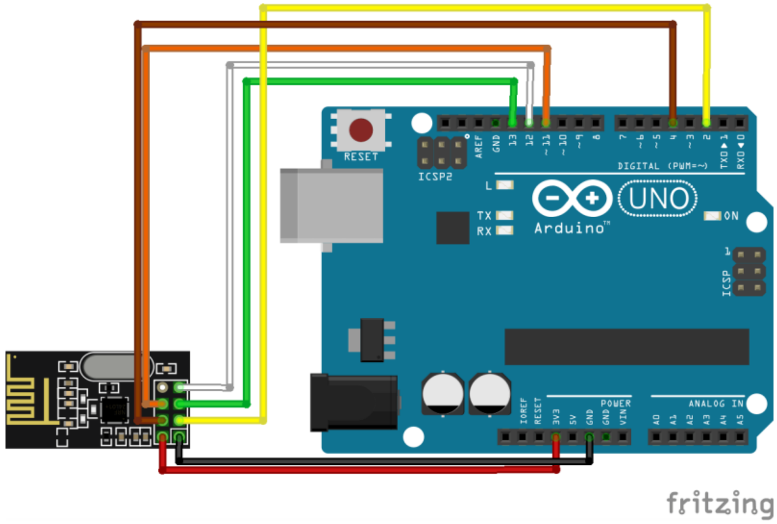

Figure 2(c): Pin connections for nRF24L01 and Arduino UNO [6]

2.3 PIR Sensor

For object detection, we use Passive Infrared Sensor (PIR) which detects the object from the infrared waves emitted by the objects in the range. The module which we have used for object detection can detect in the range of 7m and can cover 120° angle area around

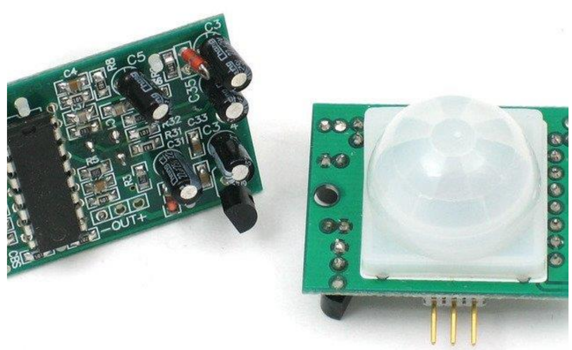

Figure: 2(d): PIR Motion Sensor

The PIR sensor itself has two slots in it, each slot is made of a special material that is sensitive to IR. When the sensor is idle, both slots detect the same amount of IR, the ambient amount radiated from the room or walls or outdoors. When a warm body like a human or animal passes by, it first intercepts one half of the PIR sensor, which causes a positive differential change between the two halves. When the warm body leaves the sensing area, the reverse happens, whereby the sensor generates a negative differential change. These change pulses are what is detected.[7]

The IR sensor itself is housed in a hermetically sealed metal can to improve noise/temperature/humidity immunity. There is a window made of IR-transmissive material (typically coated silicon since that is very easy to come by) that protects the sensing element. Behind the window are the two balanced sensors.

2.4 RTC Module

For time manipulation as in for turning on and off our system between particular time duration we use an RTC module (Real Time Clock) which will keep the record of the real world time [8].

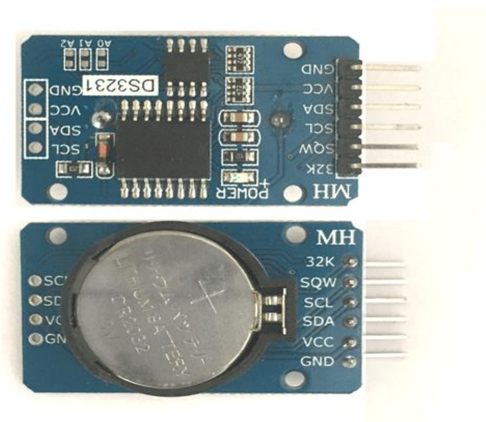

Figure: 2(e): RTC Module

RTC means Real Time Clock. RTC modules are simply TIME and DATE remembering systems which have battery setup which in the absence of external power keeps the module running. This keeps the TIME and DATE up to date. So, we can have accurate TIME and DATE from RTC module whenever we want.

Pin Name	Description
VCC	Connected to positive of power source.
GND	Connected to ground.
SDA	Serial Data pin (I2C interface)
SCL	Serial Clock pin (I2C interface)
SQW	Square Wave output pin
32K	32K oscillator output

Table III: RTC Module Pin Configuration

DS3231 is a six terminal device, out of them two pins are not compulsory to use. So we have mainly four pins. These four pins are given out on other side of module sharing the same name.[9]

2.5 LED (Light Emitting Diode)

We have used an electronic LED for the prototype development. We can embed our system with the currently existing street lights or LEDs with the help of necessary electric systems.

Figure 2(f): LED’s

A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The color of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor. White light is obtained by using multiple semiconductors or a layer of light-emitting phosphor on the semiconductor device.

In a light emitting diode, the recombination of electrons and electron holes in a semiconductor produces light (be it infrared, visible or UV), a process called "electroluminescence". The wavelength of the light depends on the energy band gap of the semiconductors used. Since these materials have a high index of refraction, design features of the devices such as special optical coatings and die shape are required to efficiently emit light.[10]

Chapter 3
Methodology

3.1 Block Diagram & Flowchart

Here the basic understanding of system working is described in the block diagram in Fig.3(a) below.

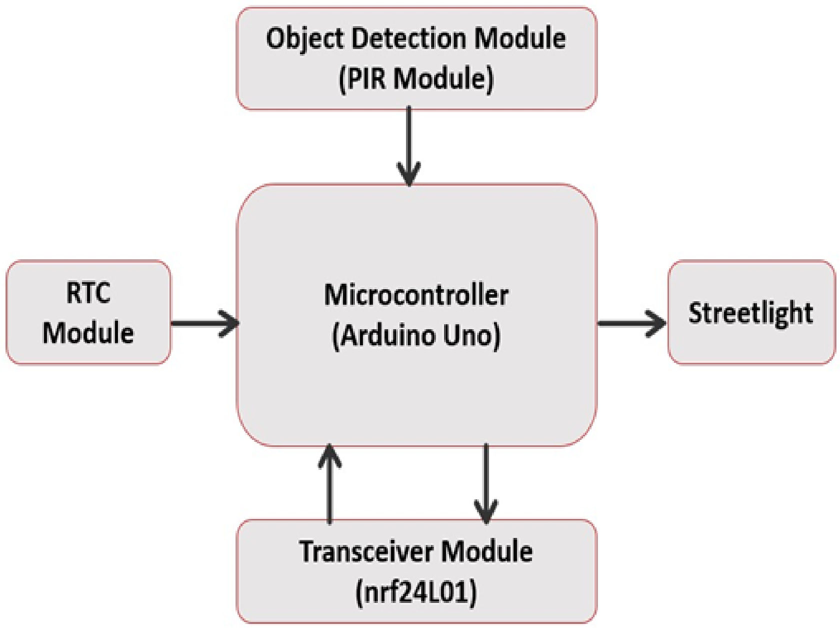

Figure: 3(a): Block Diagram

We have designed our system in such a way keeping some common requirements and conditions of various premises. We know that after a certain time when it is needed to turn on the streetlights, for a specific duration depending on the premise location and type, there will be extensive movement of objects in the premises. If we take an example of some industrial park then it might be required that at 7:00 pm, it is needed to turn on the street lights continuously up to 10:00 pm. So we have designed our system in such a way that as per the premises requirements and conditions we can turn on the proposed "Power Saving Mode" for a particular, predefined and configurable time.

So, for our example of an industrial park, the proposed system for "Power Saving Mode" will get enabled only at 10:00 pm. Till then all street lights will operate in "Continuously ON" mode. The proposed system for "Power Saving Mode" initiates when the RTC module enables the system as per the time defined in the microcontroller. So after that streetlights will turn on and turn off based on our proposed idea rather than the "Continuous ON" mode. In "Power Saving Mode" streetlight is turned on when it receives the signal from an object (vehicle or pedestrian) by the object detection module. Now object detection sensor - PIR sensor as well as nRF24L01 are interfaced with Arduino Uno respectively. nRF24L01 module being a transceiver module transmits signal from host nRF24L01 to maximum of six other guest nRF24L01 modules lying in range.

Here the "host" term refers to the streetlight where the detection of an object has taken place and the term "guest" refers to the streetlights having transceiver nRF24L01 modules which are in the range of the host streetlight's transceiver nRF24L01 module. This triggers the Arduino Uno board at the receiving side with the LED light which will turn on when signal is received from the host nRF24L01. The program in the microcontroller board is such that the LEDs get turned off after a predefined time which can be configured as per our requirements and conditions if no signal is received from either the object detection module on the system or from the other host nRF24L01 to the guest nRF24L01 modules on system. The system working flow can be understood easily from the system flowchart as shown in the Fig. 3(b) below.

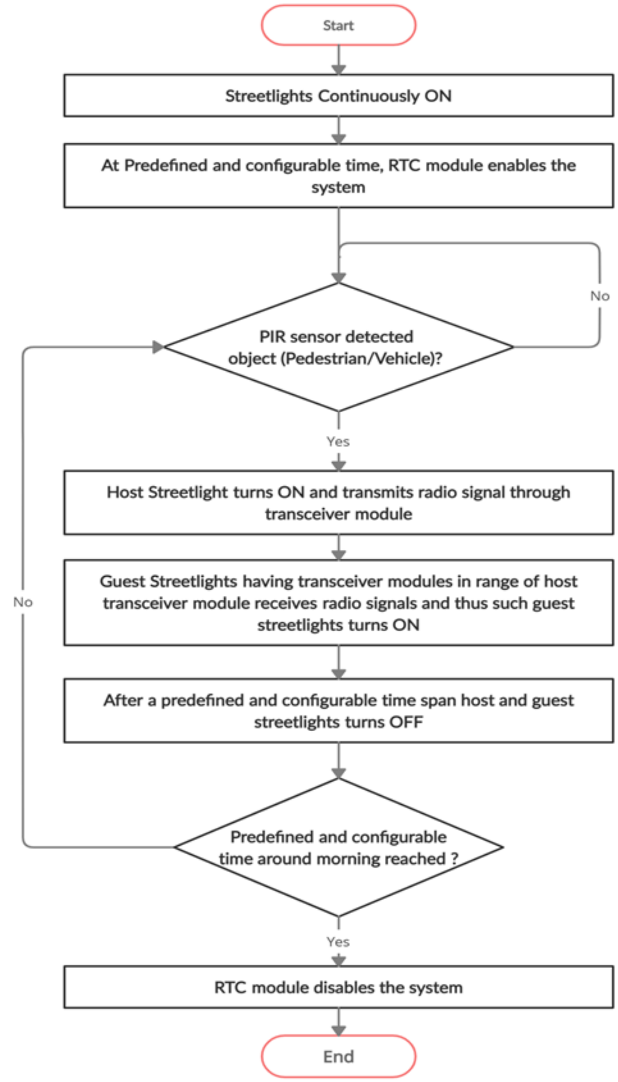

Figure 3(b): Flowchart of The System

3.2 Circuit Diagram

The circuit diagram for the proposed Smart Street Light Management System is developed by using the EasyEDA software and is shown in the Fig. 3(c) below.

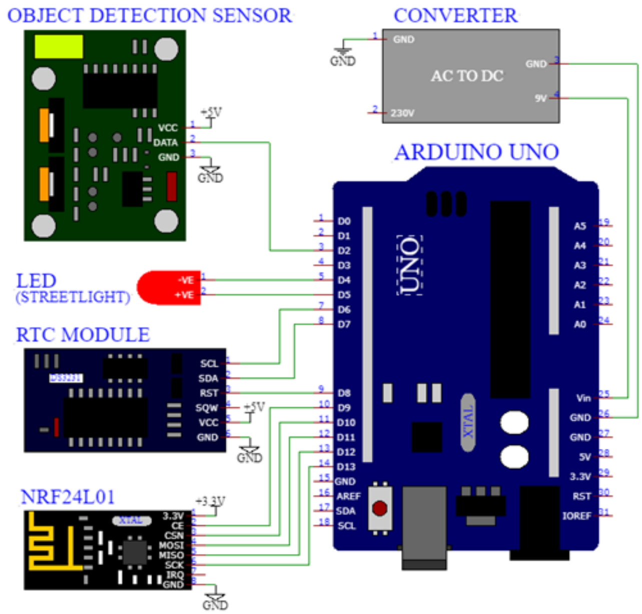

Figure 3(c): Circuit Diagram

3.3 System Working

Consider a street having streetlights at defined distance with each other as shown in Fig. 3(d) below.

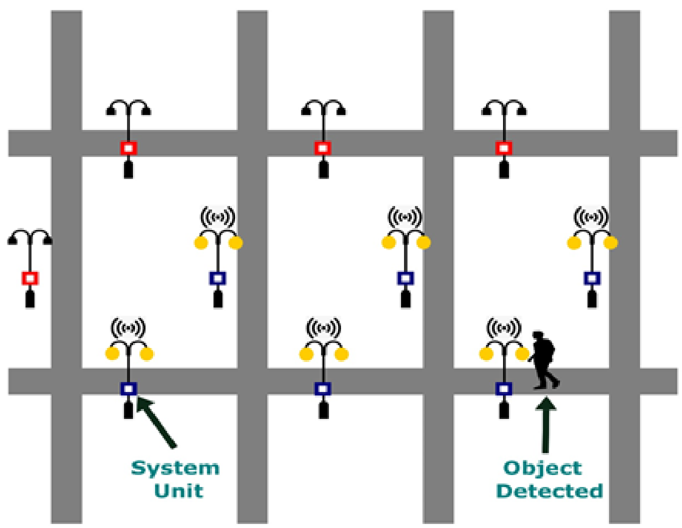

Figure 3(d): Representation of the described project view on street

After the "Power Saving Mode" is enabled at the predefined time by RTC module, assume a vehicle or pedestrian is detected at first streetlight, that particular streetlight will be turned on and at the same time a signal will be transmitted to the other streetlights which are in range of the radio transceiver module of the first streetlight which has just detected an object. Turning on the detected streetlight and transmitting and receiving of the signal by transceiver modules in the range happens in no time. As soon as the transceiver modules which are in range of the first streetlight receive a signal from the transceiver module attached to detecting streetlights, corresponding streetlights will be turned on accordingly. So, before the object has crossed the detecting streetlight, the surrounding streetlights are already turned on. We have calibrated the settings in such a way that the streetlight will get turned off after a defined time after the detection or after the receiving the transmitted signal. Range of the transceiver module - nRF24L01 is around 100m so object passing by will never feel a blackout or experience flickering of the lights since before object has crossed the first streetlight, all other streetlights in range will be turned on and as object moves ahead it keeps on getting detected by the upcoming sensors of the streetlights and hence further and further streetlights will be getting switched on according to a predefined and configurable time calibrated in the microcontroller. As we know that one nRF24L01 module can communicate with a maximum of six other nRF24L01 modules, so detection at one streetlight can turn or that detection at streetlight and more six street lights around in the range by transmission through the transceiver module. We have kept the RTC module which will help us turning on our system at particular time and turning off our system at particular time assuming between 12:00 am and 6:00 am and also it is configurable as per our requirement and it will run the system for a particular duration of time automatically without human interference. The use of a Real Time Clock module in the proposed system enables the concept implementation that assumes that streetlights are turned on at 7:00 pm in evening. But between 7 pm to 10 pm, there is a lot of traffic or it is required to keep the streetlight continuously on as per the requirements of conditions of premise. So we can set the time with the help of RTC module, so only at the 10:00 pm, the proposed system will enable itself and between 7:00 pm to 10:00 pm, the streetlight will be continuously on while after 10:00 pm, the streetlight will only turn on for defined time either by object detection or by receiving the signal transceiver module based on surrounding detection of object.

Chapter 4
Results & Future Scope

4.1 Results

The proposed Smart Street Light Management System has been tested for a few nights and results achieved are discussed below.

As we see in the below Fig. 5(a), that object has been detected by the object detection sensor and hence the LED light has been turned on. The proposed prototype does not require a lot of space and can be integrated as a small unit which can be inferred from the Fig. 4(a).

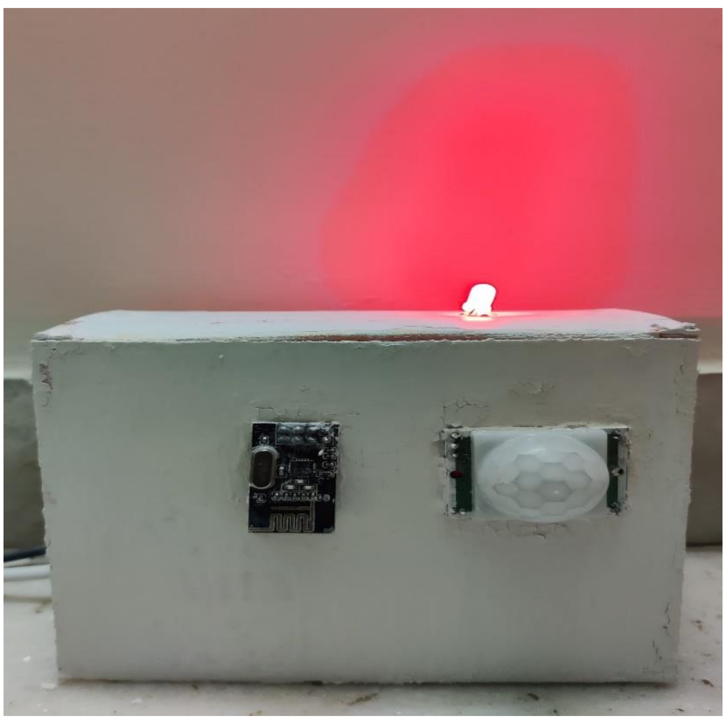

Figure 4(a): Object detection based LED operation

Here, as per the Fig. 4(b) below, in the Arduino serial com port we can see that the object is detected at 22:30:03 timestamp hence the LED streetlight is turned ON at that time. It takes the object around five seconds to pass through the detection area of the sensor. And as per the requirements of the premises, the streetlight gets turned OFF after configurable programmed time, here which is kept as 30 seconds. And it is also needed to be noted that the configurable time delay starts after the object has been stopped getting detected so if the object is pedestrian and pedestrian stops there for a while so for that case the host system will be on continuously and the configurable time delay will only get started after the pedestrian moves from the detection area. And while the pedestrian is stopped at one particular detection area that host system will keep sending the radio signal to the guest systems in range and hence surrounding systems will also have their LED streetlights on so the pedestrian will feel the continuous on operation of the streetlights on a particular street.

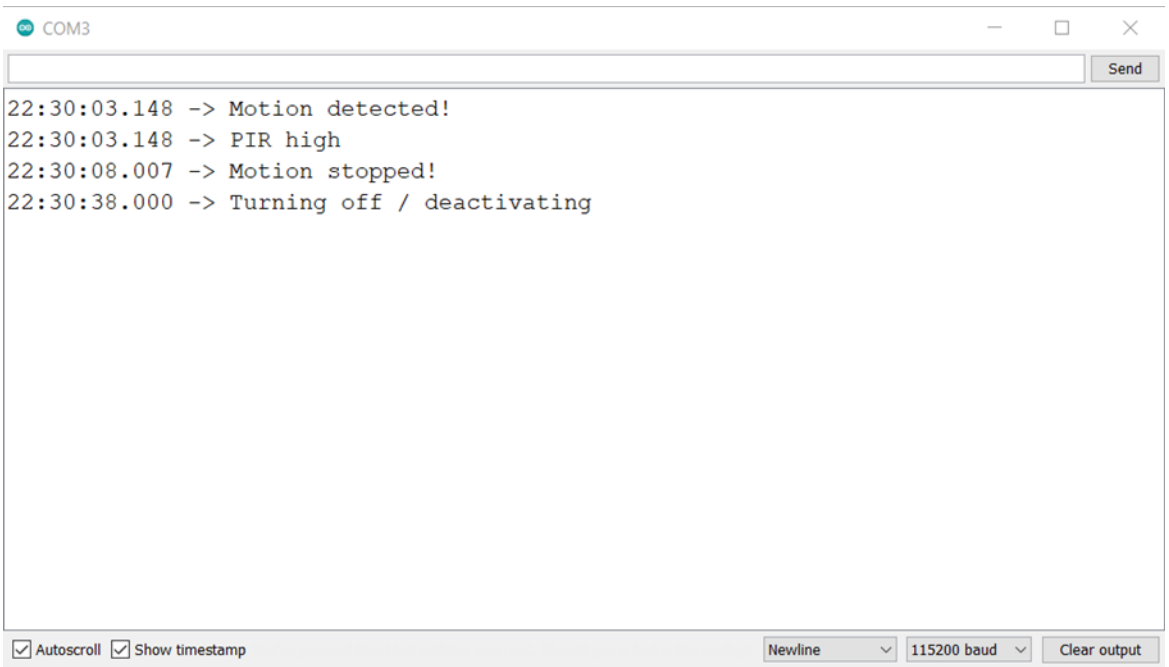

Fig. 4(b): Object detection based LED operation in serial COM port

In Fig. 4(c) there are three systems exhibited. On the left hand side in the image we can see a person is detected by one system due to that the LED streetlight of that particular streetlight has been turned ON and at the same time due to radio transmission, the other two systems which are in the range of host system has got the LEDs on as well. The radio transceiver module in the host system can communicate with other maximum of six transceiver modules in the range. And the measured range of transceiver module nRF24L01 is near to 30m and in line of sight it can transmit up to 100m which can cover enough number of streetlights in street for the object to pass on through.

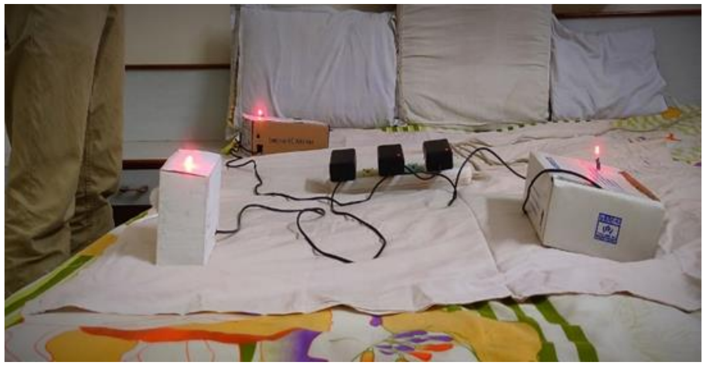

Figure 4(c): Radio transmission based LED operation

Here in Fig. 4(d), it is observed that, at 22:35:28 timestamp the RF signal is received at a guest system from the host system where the object was detected and at the same time LED street light is turned on at the guest systems. After a 30 seconds of configurable time delay at 22:35:58 the guest LED street light is turned off along with the host system.

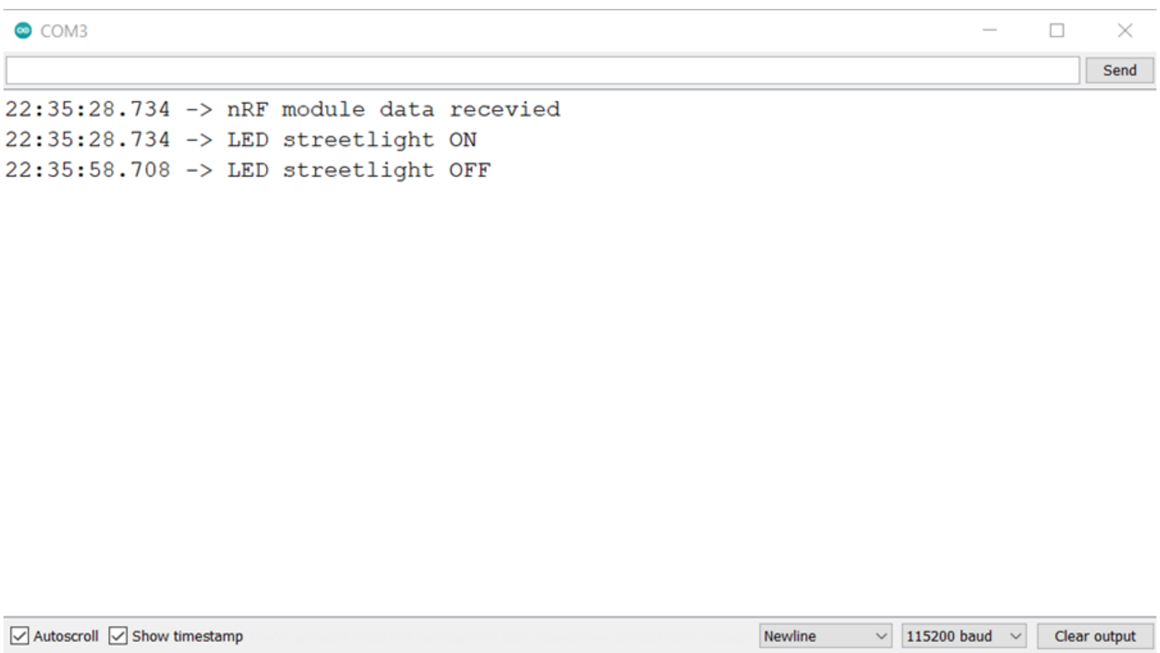

Figure 4(d): Radio transmission based LED operation in serial COM port

The Fig. 4(e) displays the internal view of a unit system having all the components connected in working conditions.

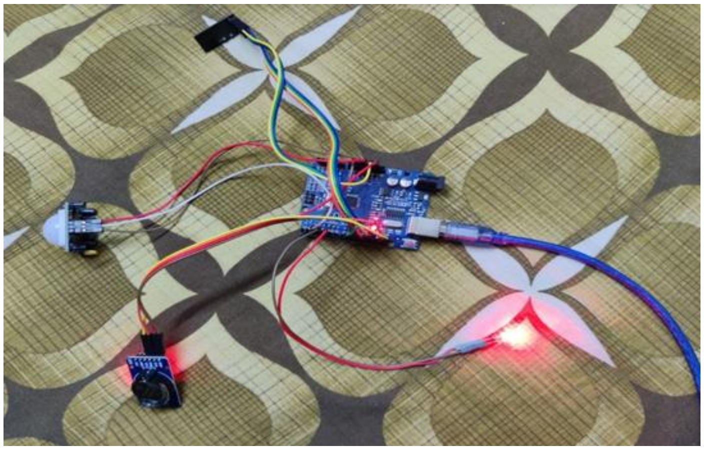
Figure 4(e): Internal working system

We have used the RTC module to configure our system to work in power saving mode from 10:00 pm to 6:00 am. And apart from this time duration, the streetlights will be working in continuously ON mode operation.

4.2 Future Scope

- This proposed system has to be implemented and connected with the existing streetlight system and has to be tested with actual conditions.
- The electronic modules having higher working efficiency can be used for increased range and more reliable results.
- The more advanced detection modules can be used for higher range and higher detection efficiency which will make the proposed idea more robust. [11]
- The system can also be used with renewable energy resources in remote locations.
- The system can be modified with integrating IoT solutions for different purposes like collecting the traffic patterns or for security purposes.

Chapter 5

Conclusion

This project discusses the requirements, design, implementation and results of Smart Streetlight Management System, a solution to reduce electricity consumption and hence reducing energy consumption. This project includes different prospects such as market scope of this project, technological aspects, cost effectiveness and benefits which are obtained by implementing the proposed design. A prototype implementation and experiment of the proposed system shows that the system works without human interference, system is easy to implement and compact and is compatible with existing street light systems. The proposed system works on low power and can easily be integrated with a pre-built power grid system in existing street light systems. This system can be implemented at various premises where it is not needed to keep the lights continuously turned on in a particular time span. Such locations include interior streets, school and college premises, industrial parks and different private and public places. Also the "on time" parameter or the delay in turning off of the streetlight after detection as explained before is configurable and can be adjusted according to the premises conditions, location weather conditions and other constraints. By implementing the proposed system, a considerable amount of electricity consumption can be reduced and hence the energy is saved along with the additional benefits of reducing the pollution and CO_2 emission.

Chapter 6

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Appendix
Budget Breakdown

Bill. No.	Component	Quantity	Total Price* (Rs.)
1	Arduino Uno	5	1500.00
2	RTC Modules	5	720.00
3	RTC Cells	5	125.00
4	AC to DC Adapter	5	750.00
5	LED’s	5	15.00
6	nrF24L01 Modules		
7	PIR Sensors		
8	Wires		320.00
	TOTAL		